

## CLAIMS

I claim:

1    1. A magnetic head comprising:  
2                 a free magnetic layer having two ends;  
3                 two hard bias layers, each adjoining a corresponding end of the free magnetic  
4                 layer, and which create a bias magnetic field within the free magnetic layer;  
5                 a bias reduction layer disposed parallel to the free magnetic layer; and  
6                 a bias spacer layer disposed parallel to and between the free magnetic layer and  
7                 the bias reduction layer;  
8                 wherein the bias reduction layer creates a magnetic field within the free magnetic  
9                 layer that is directed oppositely to the bias magnetic field.

1    2. A magnetic head according to claim 1, wherein the bias spacer layer is comprised  
2         of ruthenium or copper.

1    3. A magnetic head according to claim 1, wherein the bias spacer layer is comprised  
2         of ruthenium having a thickness between approximately 8 and 40 angstroms ( $\text{\AA}$ ).

1    4. A magnetic head according to claim 1, wherein the bias spacer layer is comprised  
2         of copper having a thickness between approximately 2 and 10  $\text{\AA}$ .

1    5.    A magnetic head according to claim 1, wherein:

2         the bias spacer layer includes a bias spacer material and has a bias spacer  
3         thickness; and

4         the bias spacer material and the bias spacer thickness are selected so as to produce  
5         a negative magnetic coupling between the free magnetic layer and the bias reduction  
6         layer.

1    6.    A magnetic head according to claim 1, wherein the bias reduction layer is  
2         comprised of NiFe or CoNiNb.

1    7.    A magnetic head according to claim 1, wherein the bias spacer reduction layer is  
2         comprised of NiFe having approximately 80 to 95% nickel.

1    8.    A magnetic head according to claim 1, wherein the bias reduction layer is  
2         comprised of CoNiNb having between 60 to 85% Co, and between 20 to 5% Ni, and  
3         between 25 to 5% Nb.

1    9.    A magnetic head according to claim 6 wherein the bias reduction layer is  
2         approximately 10 Å thick.

1    10.   A magnetic head according to claim 1, wherein:

2         the bias reduction layer includes a bias reduction material and has a bias reduction

3 layer thickness; and  
4 the bias reduction material and the bias reduction layer thickness are selected so  
5 as to produce a bias reduction magnetic field within the free magnetic layer, wherein the  
6 bias reduction magnetic field counteracts the bias magnetic field at positions within the  
7 free magnetic layer that are between ends of the free magnetic layer.

1 11. A magnetic head portion according to claim 1, wherein the hard bias layers induce  
2 an edge bias magnetic field within the free magnetic layer at the ends of the free magnetic  
3 layer, where the edge bias magnetic field is of sufficient strength to stabilize the free  
4 magnetic layer even when partially counteracted by a bias reduction magnetic field  
5 created by coupling of the free magnetic layer with the bias reduction layer.

1 12. A hard disk drive for reading and writing information in a magnetic medium, the  
2 disk drive comprising:  
3 a disk having a surface that includes the magnetic medium;  
4 a motor coupled to rotate the disk;  
5 a slider having an air bearing surface;  
6 an actuator configured to hold the air bearing surface of the slider proximate to  
7 the surface of the disk;  
8 a magnetic head disposed within the slider and forming part of the air bearing  
9 surface, wherein the magnetic head includes:  
10 i) a free magnetic layer having two ends;

11       ii)       two hard bias layers, each adjoining a corresponding end of the free  
12       magnetic layer, and which create a bias magnetic field within the free magnetic  
13       layer;  
14       iii)      a bias reduction layer disposed parallel to the free magnetic layer;  
15       iv)      a spacer layer disposed parallel to and between the free magnetic layer and  
16       the bias reduction layer; and  
17       wherein the bias reduction layer creates a magnetic field within the free magnetic  
18       layer that is directed oppositely to the bias magnetic field.

1       13.     A hard disk drive according to claim 12, wherein the bias spacer layer is  
2       comprised of ruthenium or copper.

1       14.     A hard disk drive according to claim 12, wherein the bias spacer layer is  
2       comprised of ruthenium having a thickness between approximately 8 and 40 Å.

1       15.     A hard disk drive according to claim 12, wherein the bias spacer layer is  
2       comprised of copper having a thickness between approximately 2 and 10 Å.

1       16.     A hard disk drive according to claim 12, wherein:  
2       the bias spacer layer includes a bias spacer material and has a bias spacer  
3       thickness; and  
4       the bias spacer material and the bias spacer thickness are selected so as to produce

5 a negative magnetic coupling between the free magnetic layer and the bias reduction  
6 layer.

1 17. A hard disk drive according to claim 12, wherein the bias reduction layer is  
2 comprised of NiFe or CoNiNb.

1 18. A hard disk drive according to claim 12, wherein the bias spacer reduction layer is  
2 comprised of NiFe having approximately 80 to 95% nickel.

1 19. A hard disk drive according to claim 12, wherein the bias reduction layer is  
2 comprised of CoNiNb having between 60 to 85% Co, and between 20 to 5% Ni, and  
3 between 25 to 5% Nb.

1 20. A hard disk drive according to claim 12, wherein the bias reduction layer is  
2 approximately 10 Å thick.

1 21. A hard disk drive according to claim 12, wherein:  
2 the bias reduction layer includes a bias reduction material and has a bias reduction  
3 layer thickness; and  
4 the bias reduction material and the bias reduction layer thickness are selected so  
5 as to produce a bias reduction magnetic field within the free magnetic layer, wherein the  
6 bias reduction magnetic field counteracts the bias magnetic field at positions within the

7 free magnetic layer that are between ends of the free magnetic layer.

1 22. A hard disk drive according to claim 12, wherein the hard bias layers induce an  
2 edge bias magnetic field within the free magnetic layer at the ends of the free magnetic  
3 layer, where the edge bias magnetic field is of sufficient strength to stabilize the free  
4 magnetic layer even when partially counteracted by a bias reduction magnetic field  
5 created by coupling of the free magnetic layer with the bias reduction layer.